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Identity of Florida Casuarinas

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ABSTRACT

Casuarina is a genus of trees native to tropical areas from Burma to the western Pacific and extending to temperate areas of Australia. Some species are commonly grown in southern and central Florida, and at least one is naturalized. This paper gives taxonomic guides for casuarinas in Florida, needed because natural hybrids and disparity in nomenclature have confused species identification there. We recognize only three species as having a significant presence in Florida: C. equisetifolia L., C. glauca Sieb. ex Spreng., and C. cunninghamiana Miq. Identifying characteristics are given for each species and for putative hybrids. We recommend more work on these species because of their actual and potential invasion of native vegetation and because these nitrogen-fixing trees have potential for biomass energy plantations and for industrial wood products.

Keywords: Casuarina equisetifolia, Casuarina cunninghamiana, Casuarina glauca, Australian-pine, sheoak.

The angiosperm family, Casuarinaceae, was formerly considered to have only one genus, but the revision of the family underway by Dr. L.A.S. Johnson of the National Herbarium of New South Wales, Sydney, Australia, recognizes 4 genera and 82 species. The name Casuarina is retained for a genus of 15 species, including all those discussed in this paper (Johnson 1982). All Casuarina species have evergreen, needlelike foliage and woody cones, which have prompted the misleading common name, Australian-pine, in Florida. Foliage morphology makes the genus easily recognized. Each "needle" is a series of overlapping whorls of longitudinally fused leaf bases that surround and are fused to true stelar tissue (Maiden 1917; Metcalfe and Chalk 1950). Leaf whorls overlap only slightly and each leaf terminates with a pointed tooth (the vestige of a leaf lamina); leaf-teeth thus define nodes. Some "needles" undergo secondary thickening and become stems, while others do not thicken and eventually abscise. These latter should be termed "branchlets," although some authors prefer "cladodes." The staminate inflorescence, when present, occupies the distal portion of a branchlet and is distinguished from the sterile portion by a slight thickening, shortened internodes, and ultimately the production of a single pedunculate anther behind each leaf-tooth. The genus includes trees up to 50 m tall with a native range from Burma to the western Pacific and extending to temperate areas of Australia. Site preferences and physiognomy distinguish the majority of species, but several that have been introduced around the world differ only subtly.

The casuarinas established in southern and central Florida include three species, Casuarina equisetifolia L., C. cunninghamiana Miq., and C. glauca Sieb. ex Spreng., which could be readily distinguished at a distance were the presence of hybrids not a cause of uncertainty. Natural hybrids and differences in nomenclature make American literature on the subject confusing. An August 1981 conference in Canberra, Australia, brought

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45 casuarina experts from 10 countries together (Midgley and others 1983) and initiated a continuing exchange of unpublished material, including confirmation of our diagnostic criteria for identification of Florida species. In this paper, we hope to provide taxonomic order and thus encourage further work on the genus. This information is particularly needed in conjunction with casuarinas' potential as tree crops and the concern over their actual and potential invasion of native vegetation (Morton 1980). Casuarinas are good candidates for biomass energy plantations, as well as for pulp and other industrial wood products, due to their nitrogen-fixing ability (Aldrich-Blake 1932; Bond 1983; Mowry 1933) and their very dense wood (ovendry specific gravity of all three Florida species lies between 0.8 and 1.0 (Doran and Hall 1983; Thomas and Gilmore 1962.)).

Species Names

In Australia, sheoak is the family's common name. Some writers have speculated that the prefix "she-" has an onomatopoeic origin (breezes make a unique "shee" sound as they pass through the foliage). Maiden (1917), however, notes that the early English settlers who gave the name were more interested in utility than esthetics, and that sheoak meant simply "inferior oak," probably in reference to machining and seasoning difficulties of the hard wood. Similarity to oak (Quercus) wood is in the large prominent rays, not in size or arrangement of pores.

Table 1 summarizes the nomenclature for Florida species. Long and Lakela (1971) use the three correct scientific names, but perpetuate errors in common names. Little (1979) lists only two species, C. equisetifolia and C. cristata. C. cristata Miq. (formerly known as C. lepidophloia F. Muell. (Macklin 1931)) is not present in Florida despite this and frequent other references to it in the literature. Barrett's (1956) description of C. lepidophloia is actually that of C. glauca. Similarly, Sturrock (1968) misidentifies the species "widely used throughout the Everglades region for windbreak plantings" as C. cristata despite giving a good description of C. glauca in the same work. Morton (1980) has nomenclature similar to that proposed by us, therein correcting her

Table 1.--Nomenclature of Casuarina species common in Florida

Latin names	Common names	
	Preferred	Less appropriate
Casuarina L.[a]	Casuarina Sheoak	Australian-pine
equisetifolia L.[a] (syn. C. litorea Rumph.)	Beach sheoak	Coast sheoak Beach pine Horsetail beefwood Whistling pine Ironwood
cunninghamiana Miq.	River sheoak	Cunningham pine River oak
glauca Sieb. ex Spreng.	Swamp sheoak	Brazilian oak Swamp oak

[a]Following Friis 1980.

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earlier use of C. cristata's common names for C. glauca (Morton 1974). Confusing C. glauca and C. cristata is understandable because two of the distinguishing features are cone size and shape, yet we have been unable to confirm any conebearing C. glauca of the pure type in Florida. The other aid to identification in Australia--geographic distribution--is obviously not helpful for planted individuals. The confusion possibly arose from trying to fit existing names to hybrid specimens.

Watkins and Sheehan (1975) probably had C. cunninghamiana in mind in reporting the intolerance to salt of C. lepidophloia because the latter tolerates alkaline soils of inland Australia, and C. glauca is even more salt-tolerant than C. equisetifolia; they also describe C. cunninghamiana as having 2.5-cm-diameter cones (two to three times too large). Root suckers are not a feature of C. cunninghamiana in Florida, contrary to Barrett's (1956) description.

Among Florida writers, Morton (1974) was the first to acknowledge that two subspecies of C. equisetifolia exist. C. equisetifolia ssp. incana (Benth.) Johnson (Johnson 1982) is distinguished from ssp. equisetifolia by more pronounced pubescence on developing cones and by the presence of hairs on the surface of branchlets (as distinguished from hairs in stomatal grooves, which are common to both). According to L.A.S. Johnson (pers. commun. 1983), all specimens in Florida are ssp. equisetifolia.

Wunderlin (1982) describes C. equisetifolia under its synonym, C. litorea, and erroneously calls C. glauca, scalybark beefwood (which translates from "lepidophloia"). He incorrectly describes C. cunninghamiana as having 10 to 12, sometimes 16, leaf-teeth per node, as having escaped from cultivation, and as being restricted to Lee County.

Species Descriptions[2]

Our descriptions of branchlets assume fresh (turgid) specimens and will not apply to the main axis of elongating shoots, young sprouts or seedlings, or to the upper crown of mature trees. Some details listed are barely discernible with a X 10 hand lens; good illumination and X 25 magnification are recommended. We count leaf-teeth after breaking a branchlet cleanly at a node by pulling, which leaves all teeth visible from one vantage point, or after breaking off a single internode, slitting it longitudinally with a knife and unwrapping the leaf sheath. The number of "capsules" (or, more precisely, bracteole pairs) in a cone whorl corresponds closely to the number of leaf-teeth and is easier to count in the field than leaf-teeth. Counts among adjacent branchlets may vary by at least one tooth, and among crown positions, by at least two.

Casuarina equisetifolia L.

Leaf-teeth 6-8 (mostly 7). Teeth occasionally brown-tipped, but usually becoming gradually whiter toward tip and edges. Longitudinal rib corresponding to leaf midvein sharp; stomatal trench (Metcalfe and Chalk 1950) at bottom of furrow prominent (fig. 1A), filled with often exserted hairs (hairs usually white, sometimes dark). Branchlet diameter 0.7-0.8 mm. Secondarily thickened twigs dark gray, rough, with persistent, recurved leaf-teeth.

Monoecious; i.e., flowers of both sexes usually occur on same tree. Staminate spike terminal, 0.6-2.5 (mostly 1.5) cm long, with floral bracts enveloping stamens not visible around teeth before anthesis. Cones usually abundant, 10-20 (mostly 16) mm in diameter, slightly longer than wide, covered while green with usually continuous mat of white hairs that turn rusty with age (a feature of ssp. incana). "Seed" a samara, 6-8 mm long, 500-1000/g, pale brown. Typically, does not form root suckers, coppices weakly from low stumps, but may coppice well from "stumps" taller than 1 m.

Tallest species of genus in Florida (up to 40 m). **Drab olive foliage diffuse, primarily from widely spaced**

[2]Diagnostic features are in **boldface** type.

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branches. Lateral branches originating low on stem often overtake the leader, producing a very broad, somewhat flat-topped mature tree (fig. 3). Triangular "plank-type" buttresses joining stem and root well developed, typically rising no higher than 1 m. Mature bark thin (<1 cm), hard, and lacking well-defined fissures (fig. 4). Poorly defined sections of weathered gray bark randomly slough, revealing bright red to orange color beneath. Immature bark (trees with diameters of 10-20 cm) rough, peeling in small flakes.

No other species in the family extends farther beyond Australia or has a wider distribution. According to L.A.S. Johnson (pers. commun. 1983), the native range of C. equisetifolia is bounded by a continuous curve connecting Burma, the Philippines, the Marianas, Christmas Island, the Marquesas, New Caledonia, Australia (fig. 2), Sumatra, and the Andaman Islands, then closing the circle back at Burma. In its native range, often the only tree present in the beach vegetation where it mainly occurs. Restricted to a narrow coastal strip including foreshore dunes and sandy flats immediately behind. Subspecies incana, a small tree to 10 m tall, occurs along eastern Australian and New Caledonian coasts. Subspecies equisetifolia intergrades with incana from lat. 17-21° S. in Australia; the former, a small tree to 16 m tall in Australia, but elsewhere, fast growing and 40+ m tall. Given unrestricted introductions around the world, providing opportunity for gene exchange among otherwise isolated gene pools, identification to subspecies in Florida may be futile.

Casuarina cunninghamiana Miq.

Leaf-teeth 7-10. Teeth sharply pointed, mostly appressed; narrow central portion brown with gray tip (position of brown variable). Longitudinal rib corresponding to leaf midvein distinct; stomatal trench between ribs poorly defined and individual hairs rarely visible at X 25 (fig. 1B). Branchlets thin, diameter 0.4-0.7 mm. Teeth on secondarily thickened twigs not persistent, leaving smooth, usually reddish bark.

Dioecious; i.e., male and female flowers on separate trees. Staminate spike terminal, very long, 1-5 (mostly 3) cm, and nodes densely packed; floral bracts enveloping stamens prominent around teeth even before anthesis. Cones small (6-10 mm diameter), as long as wide, with thin, glabrous bracteoles. Samaras, 3-5 mm long, 1,500-2,400/g, dull gray-brown. Does not commonly form root suckers; coppicing response in Florida has not been examined.

The largest casuarina in Australia (35 m), but smallest and least vigorous in Florida (10-15 m). Young specimens have compact pyramidal crowns with dark-green foliage conspicuously accented on male trees by yellowish staminate spikes. Lateral branches short, often curving downward. Branchlet length, foliage distribution, and branching habit make mature specimens resemble pines (fig. 5). Upper stem of mature trees often curves away from the vertical (Florida and Australia). Bole terete, without buttresses or flutings. Bark hard and thick; closely spaced fissures first developing at diameter of 7 cm, creating highly dissected, but coarse pattern (fig. 6). Bark light to very dark gray.

In native range (fig. 2), occurs mainly as pure stands along freshwater streams in narrow belts subject to periodic flooding. Distributed both sides of the Great Dividing Range in eastern Australia at altitudes up to 1,000 m; a distinct race is found in Northern Territory (Doran and Hall 1983). Distribution implies tolerance of frequent light frosts and intolerance of continuously waterlogged soils.

Casuarina glauca Sieb. ex Spreng.

Leaf-teeth 10-14 (mostly 12) [in Australia, 12-17 (mostly 14-16)]. Either entire tooth brown or brown ring where teeth unite; in latter case gray tips occasionally missing due to abrasion. Longitudinal ribs and furrows vague; stomatal trenches indistinct (fig. 1C). Branchlet diameter 0.8-1.0 mm. Secondarily thickened twigs brownish gray and rough from persistent leaf-teeth.

Dioecious. Staminate spike not

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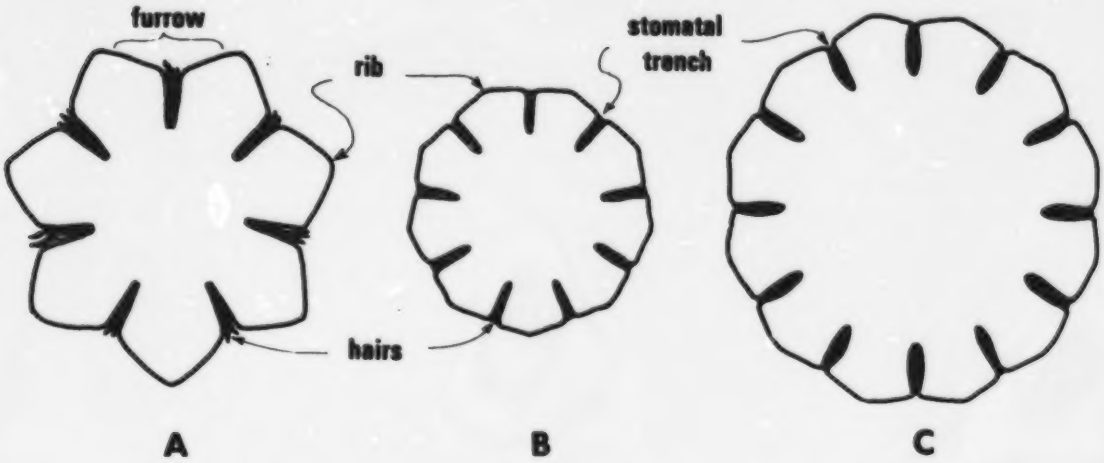

Figure 1. Outline of cross sections through branchlet internodes. Hairs in (A) Casuarina equisetifolia are raggedly exserted and in (B) C. cunninghamiana are packed so tightly that trenches are not perceived from exterior. Trench is also difficult to perceive in (C) C. glauca due to tightly packed hairs plus constricted outlet.

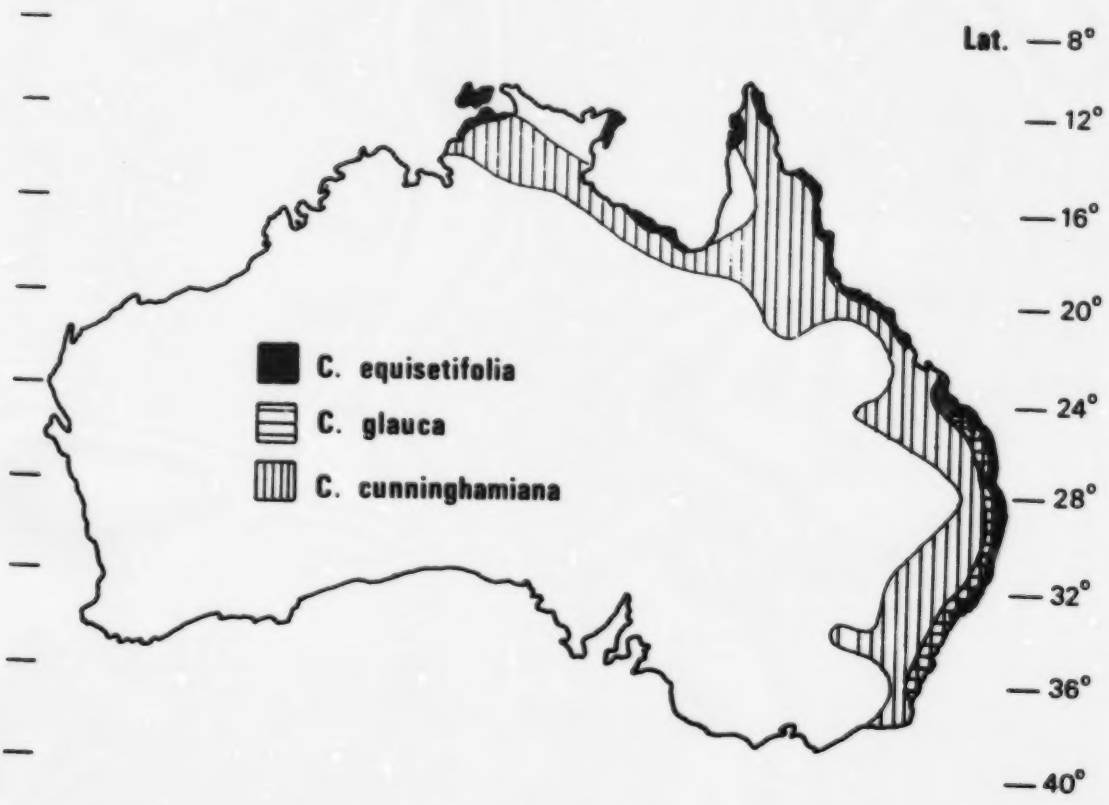

Figure 2. Native ranges of Casuarina equisetifolia, C. glauca, and C. cunninghamiana (after Doran and Hall 1983). Range of C. equisetifolia outside Australia is given in text.

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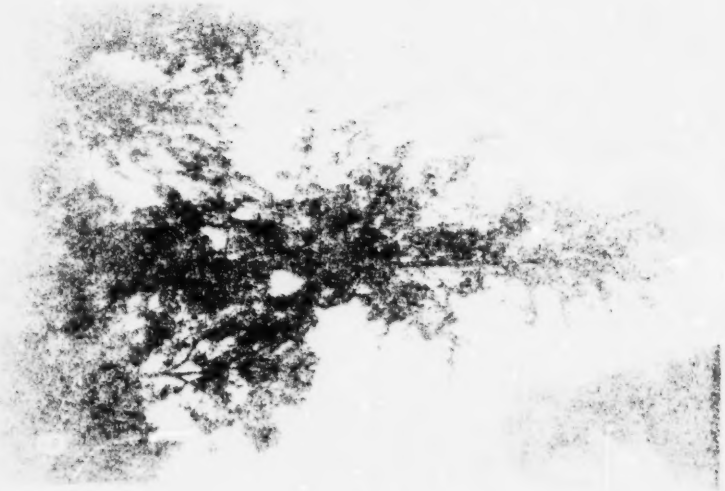
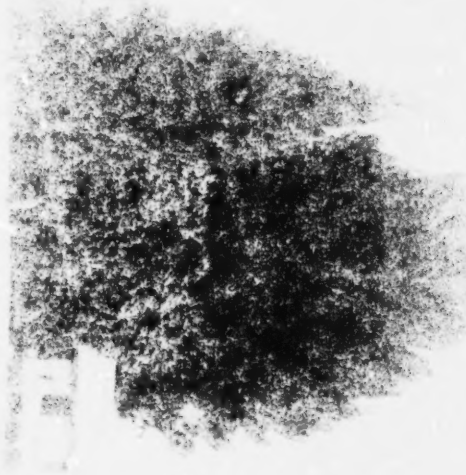
Figures 3-6. Representative specimens of cunninghamias near Fort Myers, FL. Fig. 3. *Cunninghamia unicanaliculata*, in early maturity. Fig. 4. *C. unicanaliculata*, detail of mature bark. Fig. 5. Mature *C. cunninghamiana*. Fig. 6. *C. cunninghamiana*, detail of mature bark.





clearly demarcated, terminal but occasionally with normal internodes distal to fertile segment; 1-2 cm long; floral bracts enveloping stamens not visible between teeth before anthesis. Cones not confirmed in Florida; in Australia, 10-20 (mostly 12) mm diameter, slightly longer than wide, and often pubescent when young. Samaras 3-5 mm long, 700-1,700/g, grayish or pale brown. Root suckers ubiquitous, even in absence of mother tree injury. Readily coppices from stump.

In Florida, a moderately tall (20+ m) tree, usually single stemmed. The strong tendency for lateral branches in upper two-thirds of crown to curve upward and become vertical (without overtaking leader), combined with sometimes very long branchlets, makes crown profile smooth and relatively narrow (fig. 7). Foliage of root suckers often joins lower branches such that open-grown trees may have "crown" extending to ground. Foliage a lustrous deep green, contrasting strongly with the smooth gray branches. Bole typically fluted several meters high, buttressing insignificant. Bark tight and pebbly textured up to ~20 cm d.b.h., pale, brownish gray; parallel longitudinal fissures develop on larger stems (fig. 8); even on old trees with rough bark, plates between fissures on upper stem recall the originally smooth bark.

In its native range (fig. 2), found in a narrow belt along southeastern coast of Australia, commonly fringing mangroves (Avicennia marina and Aegiceras corniculatum) along estuaries or other flats under tidal influence (permanently high water table, occasional flooding with seawater, soil solution ranging from hypo- to hypersaline relative to seawater). Sometimes associated with Melaleuca quinquenervia and Eucalyptus robusta, the latter dominating on less-poorly-drained, freshwater sites, and the former dominating sites intermediate in flooding and salinity (For. Comm. N S W 1965). C. glauca is eventually replaced by C. cunninghamiana upstream (Doran and Hall 1983). May also be found on steep slopes with skeletal soils near coast. Tolerates salt spray.

Hybrids

We find many trees in Florida that deviate substantially from any of the three preceding species descriptions, and which do not fit descriptions for any other species. Hybrids can be expected. In Australia, Casuarina spp. are typically allopatric--barriers to gene flow are more ecological than anatomical or biochemical. Hybrids of C. glauca and C. cunninghamiana are occasionally found in Australia where populations overlap, and in Egypt the C. glauca X C. cunninghamiana hybrid was found in progeny of trees growing close together in a formal garden (Badran and others 1976; El-Lakany and others 1977). Because casuarina pollen is disseminated by air currents and flowering is roughly synchronous for the three Florida species, numerous opportunities for hybridization and backcrossing have occurred, possibly before but definitely after introduction to Florida.

We suspect that various degrees of hybridization between C. equisetifolia and C. glauca are represented in Florida among planted individuals and naturalized populations. Prominent common examples have 8-10 brown leaf-teeth, very long, dark-green, limply hanging branchlets, staminate spikes identical to those of C. glauca, male and female flowers on the same tree, cones 13 mm diameter, wider than long, root suckers, a tall straight single stem with narrow crown and not strongly ascending lateral branches, fluted bole, and bark combining features of C. glauca and C. equisetifolia (figs. 9, 10). Such specimens did not experience crown dieback from severe freezes in 1981 and 1982, as did neighboring C. equisetifolia. Another suspected hybrid has ascending branches as in C. glauca, no root suckers, 8-10 leaf-teeth, and is monoecious. Monoeciousness and lack of root suckers are characteristic of C. equisetifolia and the number of leaf-teeth is intermediate between C. equisetifolia and C. glauca. Most reports of seed-producing C. glauca in Florida are probably reports of such hybrids; one's first impression is definitely of C. glauca. Numerous naturalized stands south of Homestead (Dade

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County) are hybrid swarms and include individuals occasionally misidentified as C. cunninghamiana due to overreliance on the number of leaf-teeth. C. cunninghamiana has 7-10 brown leaf-teeth but is not a suspected parent of most putative hybrids because bark, cone, or staminate spike features do not suggest it, but the existence of C. cunninghamiana X hybrids would not surprise us. We even suspect that many Florida populations identified as true C. glauca may not be completely pure because the number of leaf-teeth is typically fewer than that reported elsewhere. The practice of propagating C. glauca via root suckers raises the possibility that the genetic base of this species in Florida is very narrow and perhaps unrepresentative of typical C. glauca.

A note of caution in using root suckering as a means of identification: at least two Florida nurseries have disseminated grafted plants, with C. glauca scions on both C. cunninghamiana and C. equisetifolia rootstocks. Their objective was to produce a tree with handsome foliage and form but free of the root-suckering nuisance. The number in existence is unknown; we certainly have not recognized any.

Conclusion

Genecology studies, followed by controlled pollination studies, are needed to reveal the genetic origins of casuarinas in Florida. We await results from casuarina seed-source studies recently established in Florida, the Dominican Republic, Haiti, and Hawaii. Included are seed lots collected from natural stands of several species scattered widely across their native ranges. These plantings, perhaps the first of their kind in the world, will allow comparison of taxonomic traits under fixed environmental conditions and allow controlled pollinations to produce hybrids for study.

The present Florida populations are probably of limited usefulness in programs to breed improved genotypes for silvicultural plantings because, generally, seedlings from superior hybrid parents are highly variable and often inferior. New introductions of pure species are needed, and some work on this has already begun. Outstanding hybrid phenotypes, however, can be successfully propagated vegetatively (Midgley and others 1983). Cloning can serve as an interim step in proving the worth of casuarinas in silvicultural plantings.

New introductions may uncover C. glauca seed sources that produce seed in Florida, a worrisome possibility if the material is not wisely managed. We believe that C. glauca could become a particularly troublesome weed across a much larger proportion of southern and central Florida than could C. equisetifolia, rivaling the invasion of Melaleuca quinquenervia (Geiger 1981). Some of the putative hybrids described in this paper show hybrid vigor on waterlogged sites. As hybrid swarms develop further, the probability of truly superior genotypes arising spontaneously increases. Those persons trying to preserve native vegetation should therefore give attention to C. glauca and its hybrids, rather than focus only on C. equisetifolia. Alternatively, those persons seeking a timber resource for the vast underutilized acreage in southern and central Florida should more seriously consider Casuarina.

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The help of D.J. Boland, Division of Forest Research, CSIRO, Canberra (Australia), was indispensable. L.A.S. Johnson characterized specimens (most hybrids) we sent to him and provided many helpful review comments. D.B. Ward, Botany Department, University of Florida, Gainesville, advised us on authorities for the genus and its type species.

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